HOW TO OPERATE

the

013006/013007 SET POINT SYSTEM

GENERAL DESCRIPTION

The 013006/013007 Set Point System may be looked upon as if it were simply a programmable zero to five volt power supply. The purpose of this equipment is to provide set point instructions for electronic controllers; specifically, temperature controllers.

The system consists of two 'black boxes':

013006 Set Point Assembly
013007 Set Point Indicator/Control Station

The 013006 unit contains all the electronics of the system, and the 013007 unit is its control panel.

The system provides six adjustable set point stations. Any one of these can be connected to its output, at the direction of a remote programming device.

Six digital dials on the control panel may be used to preset these set points at the desired operating points, which may then be selected in sequence by the remote programmer. In this manner, the equipment being controlled can be automatically cycled thru a prescribed operating profile.

The control panel also includes a digital set point indicator, a deviation meter and a switch which permits manual intervention during programmed operation. The set point indicator tells which set point is currently directing the process, and the deviation meter shows where the process is operating, with respect to the set point.

The system includes a failsafe feature, which guards aginst programmer failure and improper programming. This feature allows the programmer to call for one, and only one, set point, at any given time. If two instructions are received simultaniously, or if the signal from the programmer is lost, the output will be diracted to a preset safeoperating level until the fault is cleared. This seventh set point adjustment is located inside of the 013006 unit.

In some applications, the 'front panel' features of the system may not be needed, and might not be desired. When this is the case, the 013006 unit will include six additional trimming potentiometers which can be pre-calibrated to the desired operating points, and the 013007 unit will not be provided.

HOW TO PROGRAM THE SET POINT SYSTEM

The system will accept either voltage or contact-closure program instructions from remote programmers. Although six set points are provided, they need not all be programmed. But the remote programmer must have one channel available for each set point that will be used.

PROGRAMMERS WITH VOLTAGE OUTPUTS:

The set point system will accept 0v/+5v signals from programmers of this type. The 0v level will be interpreted as an OFF instruction, and the +5v level will be interpreted as an ON instruction. The tolerances on these levels are:

OFF:	0v ±0.25v
ON:	+5v ±1v

The outputs of the programmer should be connected to TB2 of the 013006 unit, terminals 1 thru 6. These terminal numbers correspond to the set point dials or adjustments, which are also numbered 1 thru 6. A common wire from the programmer should be connected to TB2, terminal 9.

PROGRAMMERS WITH CONTACT OUTPUTS:

When programmed by equipment of this type, the set point system will interpret an open contact as an OFF instruction, and a closed contact as an ON instruction.

Since very little voltage and current is used in conjunction with these contacts, they should be of some type which is suited to low level signals, or 'dry circuit' switching. Gold plated bifurcated contacts would be ideal, in the interest of good reliability.

One side of each output contact should be connected to TB2, terminals 1 thru 6, inside of the 013006 unit. These terminal numbers identify the set point station which will be activated by each contact. The opposite sides of these contacts should all be wired to terminal 7 of TB2, which provides the sensing power.

PROGRAMMING:

Simply configurate your programmer such that at least one of the set points is on at all times, and so that no more than one will ever be on at the same time. In other words, program the system so that at the desired interval two things happen; (1) the current set point will be switched off, and (2) the next set point will be switched on.

Since the set point system will interpret no instruction and more than one instruction as a fault, the sequence of this switching action is not important. However, it should be completed within less than one second so that it will not disturb the process (during the interval between the off and on instructions, the set point system will switch to its failsafe set point).

It is not necessary to select the set points in 1–2–3 order. You may start with any set point station, and sequence from one to another in any order you wish.

A switch on the front of the control panel allows manual intervention at any time during programmed operation. To take over manually, you would simply switch from 'REMOTE' to '1'. When this is done, the output will be connected to Set Point Station 1, and the set point system will ignore the instructions received from the programmer. You may then control the operating point of the equipment manually from Station 1, without interferance by the programmer.

In connection with this manual feature, you might not want to use Set Point Station 1 as a programmed set point when you do not need all six stations for programmed operation.

UNUSED SET POINTS

If you don't need as many as six programmed set points, you might not want to connect all six to your programmer. This would leave more programmer channels available for other functions, or perhaps your programmer does not have enough channels to operate all six set point stations.

In this case, it is good practice to wire the unused program inputs to ground (terminal 9) in the 013006 unit. This will preclude any possibility of electrical interferance intermittantly triggering these unused inputs. For instance, if you don't want to use Set Point Stations 4,5 & 6, jumper wire terminals 4, 5 and 6 to terminal 9, on TB2 inside of the 013006 unit.

HOW TO ADJUST THE SET POINT DIALS

The purpose of the set point system is to provide electronic controllers with set point instructions. The term 'set point' means the point at which we want the controller to stabilize the process. For instance, if we want a temperature controller to hold the temperature at +160F, then we would provide it with some sort of instruction that, to it, would mean '+160F'.

For an electronic controller, this instruction must be presented in some electrical form which is analogous to the temperature range. This is easy to do, because we can simply say . . .

"0v to +5.0v will mean –125F to +375F"

. . . or whatever the range of the controller is. The above range is standard for many of the units manufactured by Thermotron, but any range could be accomodated in this manner. The 0v/+5v electrical signal is referred to as an 'analog of temperature'. Most all Thermotron devices are designed to deal with five volt analogs for the sake of computer compatability, this signal level having become, more or less, standard in that industry.

Generally speaking, a set point instruction of +2.5v would be analogous to a temperature of +125Funder the above convention. But there's a problem.

Because of its fast response capabilities, a thermocouple makes a good temperature sensor for control applications, where sensor response must be fast in order to achieve good control. A thermocouple developes a small electrical signal which is analogous to temperature, but this signal (or analog) is not linear. For instance, its signal may change ±17uv per degree at -125F, but ±30uv per degree at +375F.

At –125F, the thermocouple output is –3.006mv, and at +375F its output is +8.787mv. Within the controller, this low level signal is amplified to more useable levels, and rescaled so that the temperature measuring analog becomes:

0v to +5.0v = –125F to +375F

Since the thermocouple signal was nonlinear, this new analog will also be nonlinear. As a result, +2.5v actually represents +157.5F, insted of +125F.

In operation, the controller will do whatever is necessary to match the temperature measuring analog with the set point analog. Hence, if the set point analog is set at +2.5v, the resulting temperature will be +157.5F. Obviously, neither the set point analog or the temperature measuring analog is very accurate, because the sensor does not provide a linear output signal. In fact, both the set point signal and the temperature measuring signal are representative of the sensors output signal . . . not analogs of temperature in terms of degrees F, but analogs of temperature in terms of the sensor's output signal.

Example: To find the % Span and analog voltage which corresponds to +160F

1. Referring to the thermocouple calibration table, Copper vs Constantan, we find that the sensor's output at +160F is:

   +2.958mv

2. It's output at the low end of our range (–125F) is –3.006mv, so its total output change from –125F to +160F is:

   3.006mv
   + 2.958mv
   5.964mv

3. Over the entire –125F to +375F range, the output span of the sensor is:

   3.006mv *(–125F)*
   + 8.787mv *(+375F)*
   11.793mv

4. The sensor's output at +160F, in terms of percent, is:

   $\frac{5.964\text{mv}}{11.793\text{mv}} = .5057237$, or 50.57%

5. The analog voltage corresponding to +160F is therefore:

   +5.000v
   x .5057
   +2.529v

HOW TO OPERATE THE SYSTEM MANUALLY

On the front of the control panel of the set point system there is a switch labeled '1' – 'REMOTE'. During programmed operation, this switch must be set at the 'REMOTE' position. When set in this position, the set point system will accept instructions from the remote programmer.

The switch is equipped with a latching toggle, which prevents accidental changes of its position.

In order to operate the system manually, gently pull the switch toggle toward you, then move it to the '1' position. The set point indicator will change to '1', and the set point system will now disregard any further instructions from the remote programmer. You may now operate the system from Set Point Station 1. When you wish to return to programmed

In order to develop an accurate analog of temperature in terms of degrees F, it would be necessary to linearize the thermocouples output signal. Over a 500F temperature span (–125F to +375F), it would be very difficult and expensive to do this with a high degree of accuracy.

The alternative is to find a convenient way to use the analog in its present form.

To provide this convenience, we've prepared tables which relate set point dial settings to both degrees F and degrees C, in one degree incriments:

% SPAN TABLES

The '% Span' expression relates to both the thermocouple's output signal and the voltage analog of that signal. This number can be calculated quite accurately, as will be demonstrated below.

The numbers appearing in the window of the digital set point knobs are a direct read-out of the set point value, in terms of % Span.

In order to adjust a set point station to any desired temperature within the range of –125F to +375F (–87C to +190C), find that temperature on the '% SPAN TABLES'. Then set the set point knob to the number given on the tables which corresponds to the desired temperature.

Example: +160F = .5057

Thus, the set point dial should be set just shy of '506'

HOW TO CALCULATE '% SPAN':

When calculating the percent of span, four systems of engineering units are involved in the problem:

Units	Low End	Mid Pt	High End	Span
percent of span	0%	50%	100%	100%
sensor millivolts*	–3.006mv	+2.891mv	+8.787mv	11.793mv
analog volts	0v	+2.500v	+5.000v	+5.000v
degrees F	–125F	+157.5F	+375F	500F

(*) Copper vs Constantan, type T, thermocouple

The problem is, to relate 'percent of span' to degrees F. In order to do this, we must first find out what the sensor's output will be at the temperature of interest, and then compare this aginst its total output change over the entire –125F to +375F temperature range. This yields the '% Span' figure. This figure can be multiplied by five, to determine the analog voltage corresponding to this specific operating point.

operation, simply return the toggle to the 'REMOTE' position.

HOW TO READ THE DEVIATION METER

The deviation meter tells where the operating point is with respect to the set point.

This indicator receives its signal from the controller, which electronically calculates the differance, and not from the set point system circuitry.

When the indicator pointer is at the exact middle of the scale, the null point, it means that the operating point is the same as the set point: no deviation.

To the left of the null point is a green band, and to the right is an orange band. When the pointer is in the green band, it means that the operating point is lower than the set point; in the orange band it means that the operating point is too high.

The meter scale is divided into five incriments to either side of the null point. Within the controller, there is an adjustment which controlls the sensitivity of this meter. The normal setting of this adjustment is ±5%. At this setting, each incriment on the deviation meter is equal to 1%, so its full-scale range is –5% to +5% of span.

For the 500F (–125F to +375F) temperature range, 1% is about equal to 5 degrees F *(subject to the nonlinearity of the thermocouple sensor)*, so for this range, one incriment is about equal to 5 degrees F.

The 'DEV SPAN' adjustment in the controller may be set for any sensitivity between ±0% and ±5%. Before you can read the deviation meter, you must know the setting of this adjustment.

FIELD CALIBRATION PROCEDURES

for

SET POINT SYSTEM 013006/013007

PRELIMINARY INFORMATION

The 013006/013007 Set Point System has five adjustments which should be checked periodically in order to assure that the system is operating properly and accurately.

In those cases where the 013006 Set Point Assembly is used without the 013007 Set Point Indicator/Control Assembly, the 013006 unit will also include six set point adjustments which must be preset at the desired operating points.

The only equipment required in order to do these adjustments is an accurate digital voltmeter (DVM). A good digital voltmeter (Fluke Model 8000A, or equal) should always be used, insted of a VOM or VTVM, because the accuracy of the latter types seldom exceeds one or two percent.

WARNING

An electrical potential of 115 volts AC at 50-60 Hz is present on the circuit board of the 013006 Set Point Assembly, in the area of the transformer and the terminal block marked TB1. Keep your hands and tools away from this area. Should any part of your body come into contact with this potential, you might be seriously injured, directly or indirectly, as a result of

ELECTRICAL SHOCK

In the remaining areas of the circuit board low DC voltages [less than 30vdc] are less hazardous to life, however short circuiting these potentials might result in permanent damage to the equipment. So be careful when useing screwdrivers and test probes.

EQUIPMENT SAFETY

In the following procedure, take whatever steps that are necessary in order to . . .

POSITIVELY DISABLE THE EQUIPMENT

. . . that is normally controlled according to the set points produced by this system. This will assure that such equipment is not inadvertantly operated at unsafe levels during this calibration procedure.

1. POWER SUPPLY ADJUSTMENTS

The set point unit's power supply includes a +15v regulated supply and a −15v regulated supply. These two supplies are used to provide referance voltages at several points in the set point circuitry, so it is important that they be properly adjusted.

1.1. Remove the cover from the 013006 Set Point Assy by pushing its ends in gently, and pulling it straight up off of the chassis.

1.2. Connect the DVM [+] lead to R44 (brown-grey-gold-gold) on the end marked [+]. Connect the DVM [−] lead to TB2, terminal 9.

1.3. The DVM indication should now be +15.00v. If not, adjust R39 as necessary to provide this indication. R39 is adjacent to IC13.

1.4. Now connect the [+] lead of the DVM to the case of IC 3.

1.5. The DVM indication should now be −15.00v. If not, adjust R41 as necessary to produce this reading. R41 is adjacent to IC14.

2. SET POINTS CALIBRATION

This part of the procedure applies only to those systems which include the 013007 Set Point Indicator/Control Station. Its purpose is to calibrate the set point dials so that their digital read-outs will be accurate in terms of percent of span.

2.1. Connect the DVM [+] lead to TB2, terminal 21, and its [−] lead to TB2, terminal 20.

2.2. Move the switch on the set point control panel to the '1' position (up).

2.3. Turn the dial at Set Point Station 1 in the clockwise direction until it reaches the clockwise limit. Then turn the dial counterclockwise about $1/10^{th}$ of a turn to produce a digital indication of exactly 000−.

2.4. At this time, the DVM indication should be +5.00v exactly. If not, adjust R36 to produce this indication. R36 is located next to IC12 on the 013006 circuit board.

2.5. Now set 'Station 1' to the settings listed below and verify that the correct output is provided at each point. If desired, you may then trim the setting of R36 as required to optomize the accuracy over the entire span.

Dial Setting	DVM Indication
000 (cw)	+5.000v
800	+4.000
600	+3.000
400	+2.000
200	+1.000

3. SET POINT ADJUSTMENTS

This part of the procedure applies only to those systems which do not include the 013007 Set Point Indicator/Control Station. Its purpose is to preset the set point adjustments at the desired operating points.

3.1. Connect the DVM [+] lead to TB2, terminal 21, and its [–] lead to TB2, terminal 20.

3.2. Notice the seven trimming potentiometers which are located adjacent to the terminal block, marked 'SET POINTS'. The set point potentiometers are numbered 1 thru 6. The seventh adjustment is the failsafe set point adjustment, which will be adjusted later.

3.3. If you can conveniently operate the outputs of your remote programmer, you may use it to provide the set point instructions which are called for below. Otherwise, disconnect temporarily any wires which are connected to TB2, terminals 1 thru 6.

3.4. Refer to the '% SPAN TABLES' and calculate the value of the analog voltage for each one of your desired operating points. For example:

+160F = .5057 x 5v = 2.5285v
– 65F = .0895 x 5v = 0.4475v

. . . etc

3.5. To activate set points 1 thru 6, connect +5v from TB2, terminal 7, to terminals 1,2,3,4,5 & 6, one at a time. At each point, adjust the corresponding set point potentiometer so that the DVM indication is the same as the value which you calculated for that operating point in step 3.4.

3.6. When finished, reconnect any wires that were disconnected from TB2, terminals 1 thru 6 in step 3.3.

NOTE

If one of your voltage settings is higher than you can achieve by adjusting the set point adjustment (but not more than +5v)

turn the set point adjustment clockwise until the DVM indication stops increasing. Then turn R36 (adjacent to IC12) clockwise until the DVM indication is +5.00v. You may then readjust the set point to the desired operating point.

WARNING

Whenever you change the setting of R36, all of the set point adjustments will be effected. They should therefore all be readjusted to the proper operating points.

4. FAILSAFE SET POINT ADJUSTMENT

The failsafe set point will be activated when the remote programming signals are improper, and when no programming signals are received, unless the system is set for manual operation. The failsafe set point should be set to a safe operating point for the equipment which is being controlled. In temperature control systems, this set point is usually set at +75F, so that the equipment will be brought back to room temperature in the event of a programming fault.

4.1. Connect the DVM [+] lead to TB2, terminal 21, and its [–] lead to terminal 20.

4.2. Determine which set point is currently ON, then short the like-numbered terminal on TB2 to any one of the other program inputs, terminals 1 thru 6. For example, if set point 3 is now on, short terminal 3 to terminal 2 or terminal 4.

4.3. If the system includes a 013007 Set Point Indicator/Control Station, the set point indicator on the panel should now display the number '7'.

4.4 Refer to the '% SPAN TABLES' and calculate the analog voltage level which corresponds to a safe operating point for the equipment being controlled. For example:

+75F = .3352 x 5v = 1.676v

4.5. On the 013006 circuit board, find the failsafe set point adjustment, under the legend 'SET POINTS'. This adjustment is labeled '7'. Turn this adjustment as required to set the DVM reading at the value which was calculated above, in step 4.4.

COPPER vs. COPPER-NICKEL

(Copper-Constantan)

TYPE T

Temperature in Degrees F

Reference Junction at 32°F

THERMOELECTRIC VOLTAGE IN ABSOLUTE MILLIVOLTS

DEG F	0	1	2	3	4	5	6	7	8	9	10	DEG F
-190	-4.009	-4.023	-4.037	-4.051	-4.065	-4.079	-4.093	-4.107	-4.121	-4.135	-4.149	-190
-180	-3.864	-3.879	-3.894	-3.908	-3.923	-3.937	-3.951	-3.966	-3.980	-3.994	-4.009	-180
-170	-3.717	-3.732	-3.746	-3.761	-3.776	-3.791	-3.806	-3.820	-3.835	-3.850	-3.864	-170
-160	-3.565	-3.580	-3.596	-3.611	-3.626	-3.641	-3.656	-3.671	-3.687	-3.702	-3.717	-160
-150	-3.410	-3.425	-3.441	-3.457	-3.472	-3.488	-3.503	-3.519	-3.534	-3.550	-3.565	-150
-140	-3.251	-3.267	-3.283	-3.299	-3.315	-3.331	-3.347	-3.362	-3.378	-3.394	-3.410	-140
-130	-3.089	-3.105	-3.121	-3.138	-3.154	-3.170	-3.186	-3.203	-3.219	-3.235	-3.251	-130
-120	-2.923	-2.939	-2.956	-2.973	-2.989	-3.006	-3.023	-3.039	-3.056	-3.072	-3.089	-120
-110	-2.753	-2.771	-2.788	-2.805	-2.822	-2.838	-2.855	-2.872	-2.889	-2.906	-2.923	-110
-100	-2.581	-2.598	-2.616	-2.633	-2.650	-2.667	-2.685	-2.702	-2.719	-2.736	-2.753	-100
-90	-2.405	-2.422	-2.440	-2.458	-2.475	-2.493	-2.511	-2.528	-2.546	-2.563	-2.581	-90
-80	-2.225	-2.243	-2.261	-2.279	-2.297	-2.315	-2.333	-2.351	-2.369	-2.387	-2.405	-80
-70	-2.042	-2.061	-2.079	-2.098	-2.116	-2.134	-2.152	-2.171	-2.189	-2.207	-2.225	-70
-60	-1.856	-1.875	-1.894	-1.912	-1.931	-1.950	-1.968	-1.987	-2.005	-2.024	-2.042	-60
-50	-1.667	-1.686	-1.705	-1.724	-1.743	-1.762	-1.781	-1.800	-1.819	-1.838	-1.856	-50
-40	-1.475	-1.494	-1.513	-1.533	-1.552	-1.571	-1.591	-1.610	-1.629	-1.648	-1.667	-40
-30	-1.279	-1.299	-1.319	-1.338	-1.358	-1.377	-1.397	-1.416	-1.436	-1.455	-1.475	-30
-20	-1.081	-1.101	-1.121	-1.141	-1.160	-1.180	-1.200	-1.220	-1.240	-1.260	-1.279	-20
-10	-0.879	-0.899	-0.920	-0.940	-0.960	-0.980	-1.000	-1.021	-1.041	-1.061	-1.081	-10
0	-0.674	-0.695	-0.716	-0.736	-0.757	-0.777	-0.798	-0.818	-0.838	-0.859	-0.879	0
DEG F	0	1	2	3	4	5	6	7	8	9	10	DEG F
0	-0.674	-0.654	-0.633	-0.613	-0.592	-0.571	-0.550	-0.529	-0.509	-0.488	-0.467	0
10	-0.467	-0.446	-0.425	-0.404	-0.383	-0.362	-0.341	-0.320	-0.299	-0.277	-0.256	10
20	-0.256	-0.235	-0.214	-0.193	-0.171	-0.150	-0.129	-0.107	-0.086	-0.064	-0.043	20
30	-0.043	-0.022	0.000	0.022	0.043	0.065	0.086	0.108	0.130	0.151	0.173	30
40	0.173	0.195	0.216	0.238	0.260	0.282	0.303	0.325	0.347	0.369	0.391	40
50	0.391	0.413	0.435	0.457	0.479	0.501	0.523	0.545	0.567	0.589	0.611	50
60	0.611	0.634	0.656	0.678	0.700	0.722	0.745	0.767	0.789	0.812	0.834	60
70	0.834	0.857	0.879	0.902	0.924	0.947	0.969	0.992	1.014	1.037	1.060	70
80	1.060	1.082	1.105	1.128	1.151	1.173	1.196	1.219	1.242	1.265	1.288	80
90	1.288	1.311	1.334	1.357	1.380	1.403	1.426	1.449	1.472	1.495	1.518	90
100	1.518	1.542	1.565	1.588	1.611	1.635	1.658	1.681	1.705	1.728	1.752	100
110	1.752	1.775	1.799	1.822	1.846	1.869	1.893	1.917	1.940	1.964	1.988	110
120	1.988	2.011	2.035	2.059	2.083	2.107	2.131	2.154	2.178	2.202	2.226	120
130	2.226	2.250	2.274	2.298	2.322	2.347	2.371	2.395	2.419	2.443	2.467	130
140	2.467	2.492	2.516	2.540	2.565	2.589	2.613	2.638	2.662	2.687	2.711	140
150	2.711	2.736	2.760	2.785	2.809	2.834	2.859	2.883	2.908	2.933	2.958	150
160	2.958	2.982	3.007	3.032	3.057	3.082	3.107	3.131	3.156	3.181	3.206	160
170	3.206	3.231	3.256	3.281	3.307	3.332	3.357	3.382	3.407	3.432	3.458	170
180	3.458	3.483	3.508	3.533	3.559	3.584	3.609	3.635	3.660	3.686	3.711	180
190	3.711	3.737	3.762	3.788	3.813	3.839	3.864	3.890	3.916	3.941	3.967	190
200	3.967	3.993	4.019	4.044	4.070	4.096	4.122	4.148	4.174	4.199	4.225	200
210	4.225	4.251	4.277	4.303	4.329	4.355	4.381	4.408	4.434	4.460	4.486	210
220	4.486	4.512	4.538	4.565	4.591	4.617	4.643	4.670	4.696	4.722	4.749	220
230	4.749	4.775	4.801	4.828	4.854	4.881	4.907	4.934	4.960	4.987	5.014	230
240	5.014	5.040	5.067	5.093	5.120	5.147	5.174	5.200	5.227	5.254	5.281	240
250	5.281	5.307	5.334	5.361	5.388	5.415	5.442	5.469	5.496	5.523	5.550	250
260	5.550	5.577	5.604	5.631	5.658	5.685	5.712	5.739	5.767	5.794	5.821	260
270	5.821	5.848	5.875	5.903	5.930	5.957	5.985	6.012	6.039	6.067	6.094	270
280	6.094	6.122	6.149	6.177	6.204	6.232	6.259	6.287	6.314	6.342	6.369	280
290	6.369	6.397	6.425	6.452	6.480	6.508	6.536	6.563	6.591	6.619	6.647	290
300	6.647	6.675	6.702	6.730	6.758	6.786	6.814	6.842	6.870	6.898	6.926	300
310	6.926	6.954	6.982	7.010	7.038	7.066	7.094	7.122	7.151	7.179	7.207	310
320	7.207	7.235	7.263	7.292	7.320	7.348	7.377	7.405	7.433	7.462	7.490	320
330	7.490	7.518	7.547	7.575	7.604	7.632	7.661	7.689	7.718	7.746	7.775	330
340	7.775	7.804	7.832	7.861	7.889	7.918	7.947	7.975	8.004	8.033	8.062	340
350	8.062	8.090	8.119	8.148	8.177	8.206	8.235	8.264	8.292	8.321	8.350	350
360	8.350	8.379	8.408	8.437	8.466	8.495	8.524	8.553	8.583	8.612	8.641	360
370	8.641	8.670	8.699	8.728	8.757	8.787	8.816	8.845	8.874	8.904	8.933	370
380	8.933	8.962	8.992	9.021	9.050	9.080	9.109	9.139	9.168	9.198	9.227	380
390	9.227	9.257	9.286	9.316	9.345	9.375	9.404	9.434	9.464	9.493	9.523	390
400	9.523	9.553	9.582	9.612	9.642	9.671	9.701	9.731	9.761	9.791	9.820	400
410	9.820	9.850	9.880	9.910	9.940	9.970	10.000	10.030	10.060	10.090	10.120	410
420	10.120	10.150	10.180	10.210	10.240	10.270	10.300	10.330	10.360	10.390	10.420	420
430	10.420	10.451	10.481	10.511	10.541	10.572	10.602	10.632	10.662	10.693	10.723	430
440	10.723	10.753	10.784	10.814	10.845	10.875	10.905	10.936	10.966	10.997	11.027	440
450	11.027	11.058	11.088	11.119	11.149	11.180	11.211	11.241	11.272	11.302	11.333	450
460	11.333	11.364	11.394	11.425	11.456	11.487	11.517	11.548	11.579	11.610	11.640	460
470	11.640	11.671	11.702	11.733	11.764	11.795	11.826	11.856	11.887	11.918	11.949	470
480	11.949	11.980	12.011	12.042	12.073	12.104	12.135	12.166	12.198	12.229	12.260	480
490	12.260	12.291	12.322	12.353	12.384	12.416	12.447	12.478	12.509	12.540	12.572	490
500	12.572	12.603	12.634	12.666	12.697	12.728	12.760	12.791	12.822	12.854	12.885	500
510	12.885	12.917	12.948	12.979	13.011	13.042	13.074	13.105	13.137	13.168	13.200	510
520	13.200	13.232	13.263	13.295	13.326	13.358	13.390	13.421	13.453	13.485	13.516	520
530	13.516	13.548	13.580	13.611	13.643	13.675	13.707	13.739	13.770	13.802	13.834	530
540	13.834	13.866	13.898	13.930	13.961	13.993	14.025	14.057	14.089	14.121	14.153	540
550	14.153	14.185	14.217	14.249	14.281	14.313	14.345	14.377	14.409	14.441	14.474	550
560	14.474	14.506	14.538	14.570	14.602	14.634	14.666	14.699	14.731	14.763	14.795	560
570	14.795	14.828	14.860	14.892	14.924	14.957	14.989	15.021	15.054	15.086	15.118	570
580	15.118	15.151	15.183	15.216	15.248	15.280	15.313	15.345	15.378	15.410	15.443	580
590	15.443	15.475	15.508	15.540	15.573	15.605	15.638	15.671	15.703	15.736	15.769	590
600	15.769	15.801	15.834	15.866	15.899	15.932	15.965	15.997	16.030	16.063	16.096	600
610	16.096	16.128	16.161	16.194	16.227	16.259	16.292	16.325	16.358	16.391	16.424	610
620	16.424	16.457	16.490	16.523	16.555	16.588	16.621	16.654	16.687	16.720	16.753	620
630	16.753	16.786	16.819	16.852	16.886	16.919	16.952	16.985	17.018	17.051	17.084	630
640	17.084	17.117	17.150	17.184	17.217	17.250	17.283	17.316	17.350	17.383	17.416	640
650	17.416	17.450	17.483	17.516	17.549	17.583	17.616	17.649	17.683	17.716	17.750	650
660	17.750	17.783	17.816	17.850	17.883	17.917	17.950	17.984	18.017	18.051	18.084	660
670	18.084	18.118	18.151	18.185	18.218	18.252	18.285	18.319	18.353	18.386	18.420	670
680	18.420	18.454	18.487	18.521	18.555	18.588	18.622	18.656	18.689	18.723	18.757	680
690	18.757	18.791	18.824	18.858	18.892	18.926	18.960	18.993	19.027	19.061	19.095	690
700	19.095	19.129	19.163	19.197	19.230	19.264	19.298	19.332	19.366	19.400	19.434	700
710	19.434	19.468	19.502	19.536	19.570	19.604	19.638	19.672	19.706	19.740	19.774	710
720	19.774	19.808	19.843	19.877	19.911	19.945	19.979	20.013	20.047	20.081	20.116	720
730	20.116	20.150	20.184	20.218	20.252	20.287	20.321	20.355	20.389	20.423	20.458	730
740	20.458	20.492	20.526	20.560	20.595	20.629	20.663	20.698	20.732	20.766	20.801	740
750	20.801	20.835	20.869									750
DEG F	0	1	2	3	4	5	6	7	8	9	10	DEG F

* CONVERTED FROM DEGREES CIIPTS 1968).

TYPE T

NEW REFERENCE TABLES
SUPERSEDES N B S CIRCULAR #561

ALLIGNMENT, CALIBRATION & MINIMUM PERFORMANCE CHECKS

for

SET POINT ASSEMBLY 013006

PRELIMINARY INFORMATION

The 013006 Set Point Assembly is a precision device. As such, it includes several adjustments which serve to set circuit values to within closer tolerances than can be achieved through the selection of standard fixed componet values.

This procedure is intended for factory production and test, factory service, and bench level service at field repair stations. Units which can successfully meet these minimum performance requirements can be considered to be fully serviceable, and able to perform their designed functions within the limits of their specification.

EQUIPMENT REQUIRED

1. Digital Voltmeter, Fluke Model 8000A, or equal.
   [Do not use a VOM or VTVM, since the accuracy of analog type meters is not satisfactory for this procedure.]
2. Oscilloscope, Tektronix 212, or equal.
3. Resistor, 330 Ohms, ¼w, 5%
4. Resistor, 150 Ohms, ¼w, 5%
5. Variac, Superior Electric 116B, or equal.

GENERAL PROCEDURE

This procedure works through the circuitry of the Set Point Assembly in the following order:

1. D.C. POWER SUPPLY & REGULATOR CIRCUITS
2. FAILSAFE DETECTOR CIRCUITS
3. BINARY ENCODER CIRCUITS
4. SET POINT MULTIPLEXER & OUTPUT CKTS

In general, this order should be adhered to since the results that are to be achieved in a given section may be contingent upon having properly completed some procedure in a previous section.

After completing each segment of the procedure, the set up for that segment should be removed, unless the next segment calls for it to be retained.

Line power should be applied to terminals L, N and E of TB1 [Line, Neutral and Earth] from the variac, which should be set at 115vac unless otherwise specified in the procedure.

Unless otherwise specified, terminals 4 and 7 of TB2 are to be jumpered togather during all tests. This is especially important in connection with the power supply checks, where incorrect readings may result if this rule is not followed.

A 013007 Set Point Indicator/Control Station must be connected to the 013006 Set Point Assembly during this procedure. Wiring information is given on drawing 470271. This switch on the 013007 unit must be set at 'REMOTE', unless otherwise specified. The set point dials should be set as follows:

Set Point	1	200
	2	400
	3	600
	4	800
	5	1000
	6	0000

1. D.C. POWER SUPPLY & REGULATOR CIRCUITS

The power supply system produces four dc potentials; ±30v unregulated and ±15v regulated. Checks include:

1.1. Unregulated voltage levels
1.2. Regulated voltage levels
1.3. Line regulation
1.4. Load regulation
1.5. Nominal load current
1.6. Current limit operation
1.7. Oscillation, Noise & transient response

1.1. Unregulated Voltage Levels

On TB2, jumper terminal 4 to terminal 7

Connect the DVM [+] lead to IC13-3, and its [–] lead to ground. Set the line voltage at 115vac [variac]. The DVM should indicate +25v, ±4v.

Connect the DVM between IC14-5 and ground. With the line voltage at 115vac, the DVM should indicate –29v ±4v.

1.2. Regulated Voltage Levels

Connect the DVM between IC13-8 and ground. Set the line voltage at 115vac. The DVM should indicate +15.00v. If not, adjust R39 to provide this indication.

Connect the DVM between IC14-8 and ground. With the line voltage at 115vac, the DVM indication should be –15.00v. If not, adjust R41 to produce this indication.

1.3. Line Regulation

Connect the DVM between IC13-8 and ground. The specified line voltage range for the set point system is 90vac to 130vac. As the line voltage is varied between these limits, the DVM indication must remain within the limits of +14.98v to +15.02v.

Connect the DVM between IC14-8 and ground. Repeat the above procedure for the –15v supply. The DVM indication must remain within the limits of –14.98v to –15.02v.

1.4. Load Regulation, Load Current & Current Limit

Connect the DVM across R44. The DVM indication will be about 280mv, ±20mv. This represents a nominal load current of about 156mA.

Connect the DVM between IC13-8 and ground. Connect a 330 ohm resistor between the leads of the DVM. This increases the load current to about 200mA. When this is done, the DVM indication should remain within the limits of +14.98v and +15.02v.

Disconnect the resistor, and connect the DVM across R44. Now short IC13-8 to ground. The DVM indication should now rise to between 345mv and 405mv. This represents a current limit of between 192mA and 225mA.

Leave the short in place, and connect the DVM between IC13-8 and ground. The DVM indication will be about +.01v. When the short is removed, the indication will immediately recover to within the limits of +14.98v and +15.02v.

Connect the DVM across R43. The DVM indication will be about 80mv ±10mv. This represents a nominal load current of about 15mA.

Connect the DVM between IC14-8 and ground. Connect a 150 ohm resistor between the leads of the DVM. This increases the load current to about 100mA. When this is done, the DVM indication should remain within the limits of −14.98v and −15.02v.

Disconnect the resistor, and connect the DVM across R43. Now short IC14-8 to ground. The DVM indication should rise to between 590mv and 690mv. This represents a load current limit of between 115mA and 135mA.

Leave the short in place, and connect the DVM between IC14-8 and ground. The DVM indication will be about −.01v. When the short is removed, the indication will immediately recover to within the limits of −14.98v and −15.02v.

1.5. Oscillation, Noise & Transient Response

Connect the oscilloscope between IC13-8 and ground. The combined amplitude of any oscillation, noise and transient spikes should not exceed 20mv peak to peak.

Connect the oscilloscope between IC14-8 and ground. The same limits apply to this point; the composit signal not exceeding 20mv peak to peak.

2. FAILSAFE DETECTOR CIRCUITS

The failsafe detector circuits monitor the program inputs in order to protect aginst improper programming signals, and the loss of program instructions. Checks include:

2.1. Input conversion levels
2.2. Input summing
2.3. Trip points
2.4. Detector output signal

2.1. Input Conversion Levels

Connect the DVM between IC1-6 and ground.

A jumper wire is already connected between terminals 4 and 7 of TB2. Disconnect the end of this wire that is connected to terminal 4, then alternately touch it to terminals 1,2,3,4,5 and 6. At each point, the DVM must indicate within the range of –4.00v to –6.00v.

2.2. Input Summing

Retaining the above set up, connect the loose end of the jumper wire to TB2, terminals 1 and 2. The DVM indication must now be within the limits of –8.00v to –10.00v.

Now disconnect the wire from terminals 1 and 2. All the terminals from 1 through 6 on TB2 should now be open [no connections]. The DVM indication must now be within the range of –1.0v to +1.0v.

Reconnect the jumper wire between terminals 4 and 7 of TB2.

2.3. Trip Points

Connect the [+] lead of the DVM to IC2-2, and its [–] lead to ground. The DVM indication must now be within the range of –2.25v to –2.75v.

Connect the DVM [+] lead to IC3-3. The DVM indication must now be within the range of –7.25v to –7.75v.

2.4. Detector Output Signal

Connect the [+] lead of the DVM to IC3-6, and its [–] lead to ground. The DVM indication must now be within the range of –0.5v to +0.5v.

Now disconnect the end of the jumper wire from TB2, terminal 4, momentarily. With the wire disconnected, the DVM indication must be within the range +13.5v to +15.0v.

3. BINARY ENCODER CIRCUITS

The binary encoder circuits monitor the program inputs and develop a three bit binary signal, on parallel lines, which tells the set point indicator system which input is active. The following procedure checks the codeing accuracy and logic signal levels.

NOTE

In the following checks, the voltage tolerances are:

0v: +0.4v max
5v: +4.5v min

3.1. Input '0'

Disconnect the jumper wire from TB2, terminal 4. Terminals 1 through 6 of TB2 should now be open.

Connect the DVM [–] lead to ground, and its [+] lead alternately to terminals 11, 12 and 13 of TB2. The DVM indication at each terminal must be +5v.

3.2. Input '1'

Connect the loose end of the jumper wire to TB2, terminal 1.

Connect the DVM [+] lead alternately to terminals 11, 12 and 13 of TB2; then to the transistors as indicated:

TB2-11:	0v	Q4c:	+5v
TB2-12:	0v	Q3c:	+5v
TB2-13:	+5v	Q2c:	0v

3.3. Input '6'

Disconnect the jumper wire from terminal 1, and connect it to terminal 6.

Useing the DVM, verify the following logic levels:

TB2-11:	+5v	Q4c:	0v
TB2-12:	+5v	Q3c:	0v
TB2-13:	0v	Q2c:	+5v

3.4. Input '7'

Retaining the above set up, connect a second jumper wire between terminals 5 and 6.

Connect the [+] lead of the DVM to Q1c. The DVM indication will be 0v.

Now remove the second jumper, so that only terminal 6 is connected to terminal 7 of TB2. The DVM indication will now be +5v.

3.5. Final Code Check

Now disconnect the jumper wire from terminal 6, then, while watching the set point indicator on the 013007 unit, connect the loose end of the jumper wire alternately to terminals 1 through 6 of TB2, and verify that the indicator displays the proper numeral for each connection:

TB2 Connection	Indicator Read-Out
none	7
1	1
2	2
3	3
4	4
5	5
6	6
any two	7

4. SET POINT MULTIPLEXER & OUTPUT CIRCUITS

The set point multiplexer consists of analog gates, which alternately connect the set point adjustments to the output buffer circuit. The following procedure checks the operation of these gates, set point calibration, failsafe operation and offset voltage in the output circuitry.

Connect the DVM between TB2 terminals 20 [–] and 21 [+].

Disconnect the jumper wire from terminal 4 of TB2, then alternately reconnect it as shown below, doing the adjustments as specified and verifying the output values listed:

TB2 Connection	DVM Indication
6	0.000v ±.015v
5	5.000v "

If not, adjust R36 as required to provide this indication

4	4.000v "
3	3.000v "
2	2.000v "
1	1.000v "
none	1.676v "

If not, adjust R13, 'S.P. 0', to provide this output level

Reconnect the jumper wire to terminal 4 of TB2, then connect the oscilloscope between terminals 20 and 21 of TB2.

The peak to peak amplitude of any noise, transient spikes or oscillation, as seen on the scope, should not exceed 20mv.

PROCEDURAL VARIATIONS

for

013006 UNITS WITH INTEGRAL SET POINT POTS

GENERAL

When the 013006 Set Point Assembly is to be used without the 013007 Set Point Indicator/Control Station, it will be provided with potentiometers R14 through R19, which are not otherwise installed.

When this is the case, the written procedures must be altered as follows:

1. HOW TO OPERATE . . .

2. FIELD CALIBRATION . . .

   The applicable variations have been included in these procedures.

3. ALLIGNMENT, CALIB.,& MIN PERFORMANCE CKS

   The 013007 unit will not be used in this test. In section 4 of this procedure, the integral set point adjustments should be set to the values listed for that test.

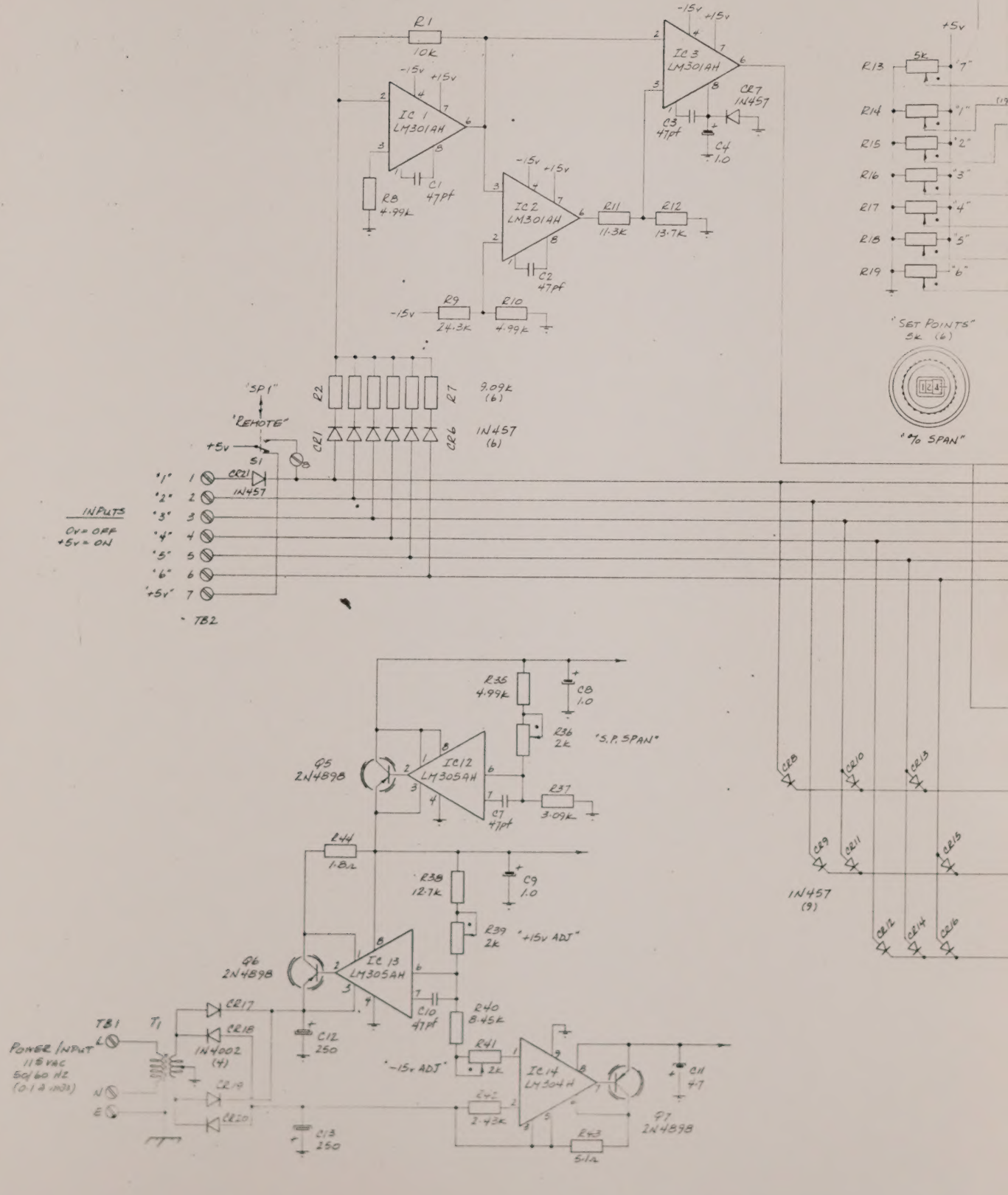
4. BURN IN . . .

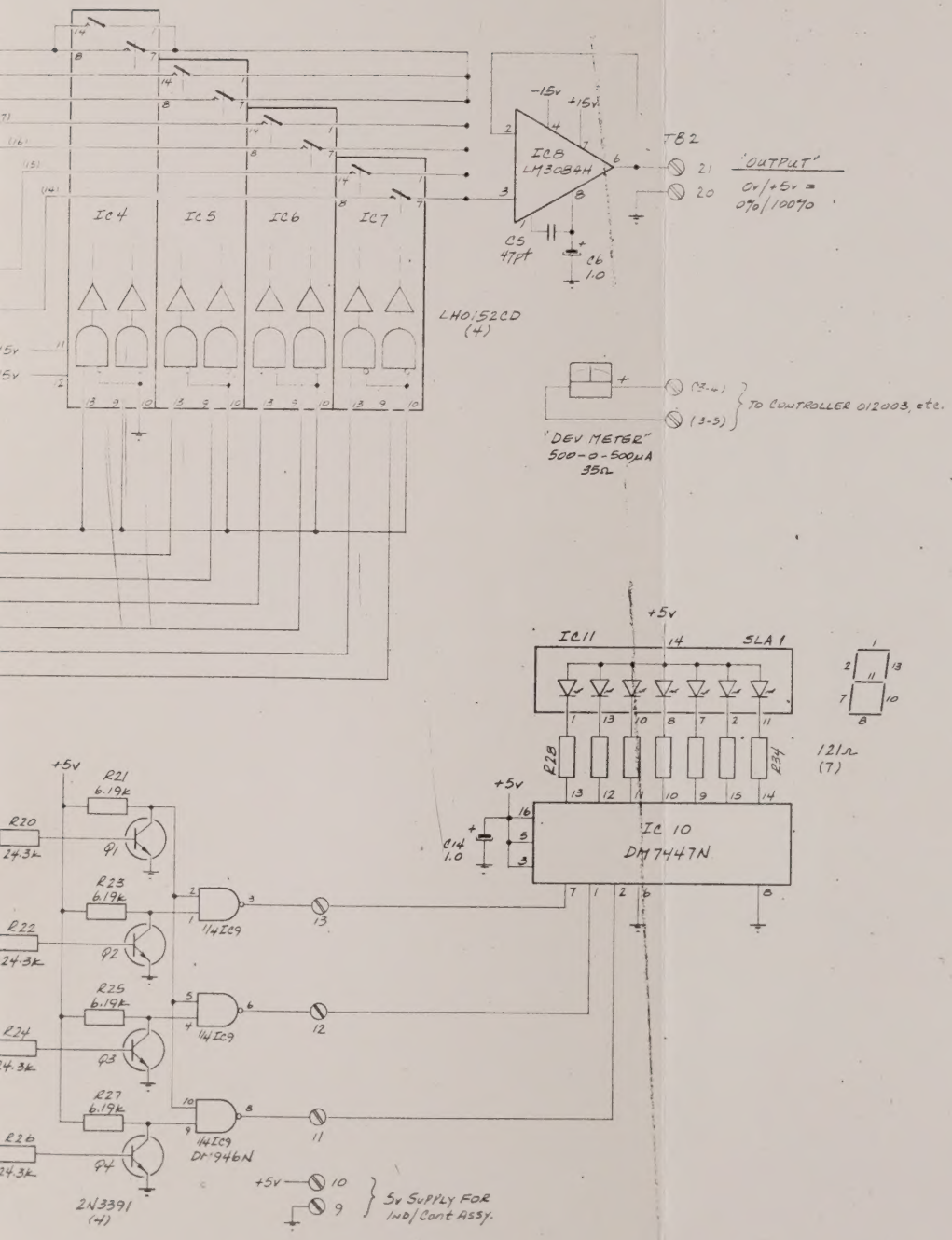
   The 013007 unit will not be used in this test. The integral set point adjustments should be set to the values given in section 4 of the Allignment, Calibration and Minimum Performance Checks.

5. FINAL TEST . . .

   The 013007 unit will not be used in this test. The integral set point adjustments should be set to the values given under item 4 of this procedure.

In all cases, those parts of the procedure which call for some action or observation involving the 013007 unit may be omitted.


R1
10K
IC 1
LM301AH
IC 2
LM301AH
IC 3
LM301AH
-15v
+15v
R8
4.99K
C1
47pf
C2
47pf
C3
47pf
C4
1.0
CR7
IN457
R9
24.3K
R10
4.99K
R11
11.3K
R12
13.7K
R13
5K
"7"
R14
"1"
R15
"2"
R16
"3"
R17
"4"
R18
"5"
R19
"6"
+5v
"SET POINTS"
5K (6)
"% SPAN"
"SP1"
"REMOTE"
S1
+5v
R2
R7
9.09K
(6)
CR1
CR6
IN457
(6)
INPUTS
0v = OFF
+5v = ON
"1" 1
"2" 2
"3" 3
"4" 4
"5" 5
"6" 6
"+5v" 7
CR21
IN457
TB2
R35
4.99K
C8
1.0
R36
2K
"S.P. SPAN"
Q5
2N4898
IC12
LM305AH
R37
3.09K
C7
47pf
R44
1.8K
R38
12.7K
C9
1.0
R39
2K
"+15v ADJ"
Q6
2N4898
IC 13
LM305AH
C10
47pf
R40
8.45K
R41
2K
"-15v ADJ"
IC 14
LM304H
C11
47
R43
5.1K
Q7
2N4898
C12
250
C13
250
2.43K
CR8
CR10
CR12
CR14
CR16
CR9
CR11
CR15
IN457
(9)
CR17
CR18
IN4002
(4)
CR19
CR20
TB1
T1
POWER INPUT
115 VAC
50/60 HZ
(0.12 AMPS)
L
N
E



REV			
1			ADD [illegible]

SCHEMATIC DIAGRAM

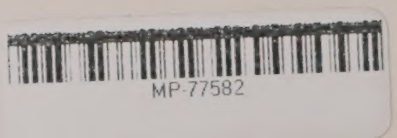
SIX STATION SET POINT ASSEMBLY

REF: 013006 & 013007

470249

GARNER
25FEB73

THERMOTRON CORPORATION HOLLAND, MICHIGAN U.S.A.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